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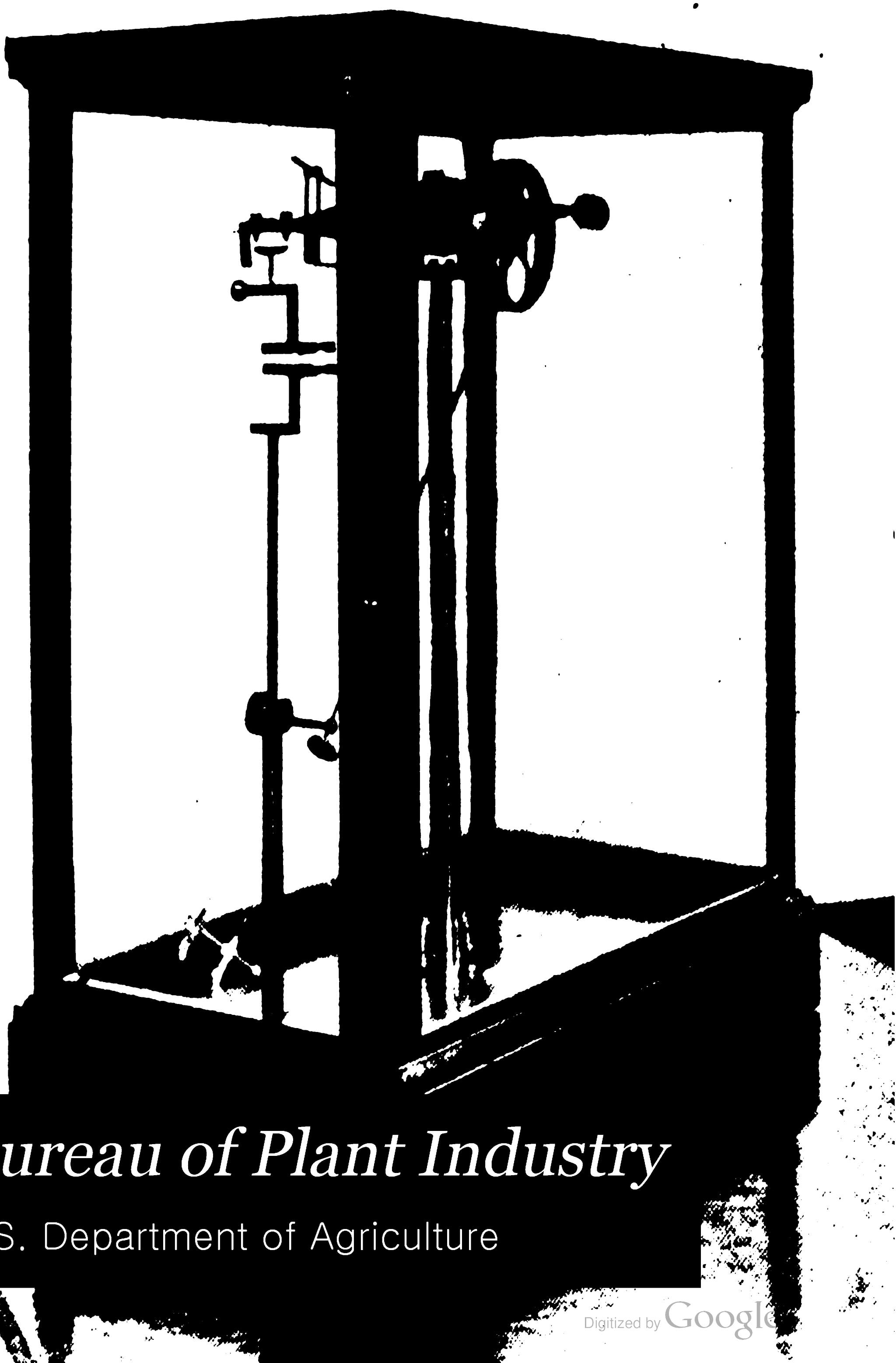

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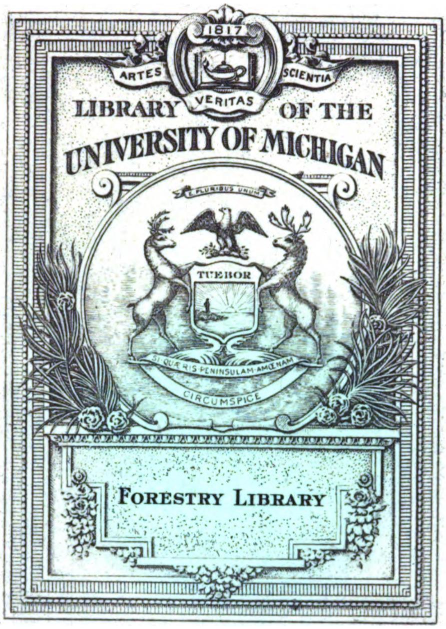

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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF PLANT INDUSTRY—Circular No. 128

WILLIAM A. TAYLOR, Chief of Bureau.

MISCELLANEOUS PAPERS.

Some Profitable and Unprofitable Farms in New Hampshire .	FRED E. ROBERTSON and LAWRENCE G. DODGE
The Strength of Textile Plant Fibers	LYSTER H. DEWEY and MARIE GOODLOE

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[Cir. 128—A]

SOME PROFITABLE AND UNPROFITABLE FARMS IN NEW HAMPSHIRE.[1]

By FRED E. ROBERTSON, *Scientific Assistant*, and LAWRENCE G. DODGE, *Agriculturist*, *Office of Farm Management.*

INTRODUCTION.

A detailed study of the financial results of farming was made in two typical dairying sections of New Hampshire. Of these localities one was in the Suncook Valley, comprising the greater portion of six towns,[2] Barnstead in Belknap County, and Pittsfield, Chichester, Epsom, Pembroke, and part of Loudon, in Merrimack County, and the other along the Connecticut River, in Grafton County, including Haverhill, Piermont, and part of Bath.

Each real farm in those areas was visited by a representative of the United States Department of Agriculture and the New Hampshire College Agricultural Experiment Station. Statements of the total investment, the receipts, expenditures, and other details of the year's business were obtained from the farmers. These statements were from the farmers' own careful estimates or, wherever possible, their actual records.

Similar investigations were made in four towns in southern New Hampshire in 1909.[3] In the region then covered there was little of the typical dairy farming of New England. The present areas were selected to show something of the financial results of dairying under average conditions, both in the production of market milk and of cream for the creameries. The region in the Suncook Valley is primarily a market-milk region, while that in Grafton County, though some milk is shipped, is more especially a creamery region.

In the two regions 428 farms in all were recorded and the financial results tabulated. In the study of these farms there appeared a wide variation in profitableness among them. To bring out the relation between some of the methods of management of the farms and the profits the most profitable 100 farms were compared with the least profitable 100.

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[1] Issued May 24, 1913.

The survey in which the material for this circular was obtained was made cooperatively by the New Hampshire College Agricultural Experiment Station and the Bureau of Plant Industry, U. S. Department of Agriculture.

[2] The term "town" as here used is synonymous with the word "township" as used in most parts of the country.

[3] The results of these investigations have been published by the U. S. Department of Agriculture in Circular 75 of the Bureau of Plant Industry.

EXPLANATION OF TERMS USED.

To make the discussion more brief and clear, a few of the terms used will be defined here:

Capital.—The term "capital" as used here relates to the value of the farm and all the equipment; it includes the value of the real estate, the machinery, tools, live stock, hay, grain, seed, etc., plus the amount of cash ordinarily kept on hand. The average of the amounts of capital at the beginning and at the end of the year, April 1, 1910, and March 31, 1911, is considered the average capital invested in the farm business for the year.

Receipts.—"Receipts" include all the money received from the sale of any product of the farm, including live stock, or for any labor of man or team performed off the farm, or for rent or the like. If the amount of capital at the end of the year is greater than at the beginning of the year, either as a whole or in some one class, such as live stock, this difference would be included in the receipts. When referred to separately it will be called "increased inventory."

Expenses.—"Expenses" include all outlay for the farm, such as cash paid for labor, feed, taxes, etc., but do not include any household or personal expenses of the farmer or his family. Any decrease in the amount of capital during the year, or "decreased inventory," is treated as an expense.

Unpaid family labor.—"Unpaid family labor" is properly an item of expense. It is the value of the labor of the other members of the farmer's family while assisting in the farm work (not in household work). It will be treated here separately from other items of expense.

Farm income.—"Farm income" is the difference between the total receipts and the total cash expenses. The farm income includes the value of the combined efforts of the farmer, of those of his family who help him, and of the use of the capital which he has invested in the farm business.

Labor income.—"Labor income," or the "farmer's labor income," represents what the farmer has earned by his own labor and supervision. It is found by subtracting from the farm income the value of the unpaid family labor and also 5 per cent interest on the capital invested.

No account has been taken of the perquisites the farm furnishes to the farmer, such as a house to live in, firewood, milk, and vegetables. The farmer's labor income can, however, be easily compared to the cash wages of a farm hand of the better class, who is furnished a house, firewood, the opportunity to make a garden, etc.

PROFITABLE AND UNPROFITABLE FARMS COMPARED.

The averages of the group of 100 profitable farms (called in the tables "better farms") are strikingly different in many respects from those of the other group (called the "poorer farms"). Certain factors will be found in the following tables to differ as widely as the difference in profits (labor income), while in other respects the average for the farms of one group does not differ appreciably from that of the other group. Care was taken to eliminate from this comparison those farms which made large profits or losses because of some unusual condition, such as the sale of a large quantity of lumber or a loss due to an unusual crop failure.

TABLE I.—*Comparative area of 200 selected farms and of all the 428 farms in New Hampshire of which data were obtained.*

Area.	100 better farms.	100 poorer farms.	Average, 428 farms.
	Acres.	*Acres.*	*Acres.*
Tillable	50	44	43.2
Pasture	130	109	99.8
Woodland	23	29	30.5
Total	203	182	173.5

The difference in acreage is slight, as shown in Table I. The group of better farms has an average of only 21 acres more land per farm than the poorer group and only 6 acres more of tillable land. When it is considered that the labor income of the farmers on the better farms averages $830 and that those farmers on the poorer farms have a minus labor income averaging $341 (meaning that they are $341 short of beginning to earn any pay for their own time), the small difference in acreage does not seem to offer an adequate explanation for the great difference in income.

One more point is to be considered: When these same 200 farms are redivided on the basis of tillable acreage, the 100 having the largest tillable acreage have an average labor income of $311, while the 100 with the smallest tillable acreage have an average of $190. This would indicate that acreage is certainly one factor that counts in determining the labor income, although the small difference in acreage between the 100 better and the 100 poorer farms suggests that it is not so important a factor as it has proved in other regions where a similar study has been made.

TABLE II.—*Comparative distribution of capital on 200 selected farms and on all the 428 farms in New Hampshire of which data were obtained.*

Item.	100 better farms.	100 poorer farms.	Average, 428 farms.
Machinery and tools	$453	$351	$352
Real estate	4,864	5,332	4,404
Live stock	1,592	1,045	1,152
Grain and feed	145	106	106
Cash to run business	163	144	137
Total	7,217	6,978	6,151

The poorer farms are here shown to have a little less total capital than the better farms, a difference of $2.39 per farm, but this is so small as to offer no reason for any great difference of earning power between the two groups.

A marked difference exists between the two groups in the distribution of capital, however. The better farms have a much smaller part of their total capital in the form of real estate and a proportionately larger part in working capital of various kinds, including live stock, machinery and tools, grain and feed, and cash to run the business. With their total capital nearly equal, the better farms have 42 per cent more working capital than the poorer farms. Expressed in another way, the better farms have 32.6 per cent of their total capital as working capital and the poorer have only 23.5 per cent in working capital. The latter illustrates quite well the old expression "land poor." This condition is often varied by having relatively too much money involved in another form of real estate, namely, buildings. Figure 1 illustrates the size and quality of buildings which are out of proportion to the income from the average farm of these two regions. With a slightly less acreage and a little less total capital the poorer farms still have a larger valuation of real estate. Too expensive buildings are a factor contributing largely to this condition.

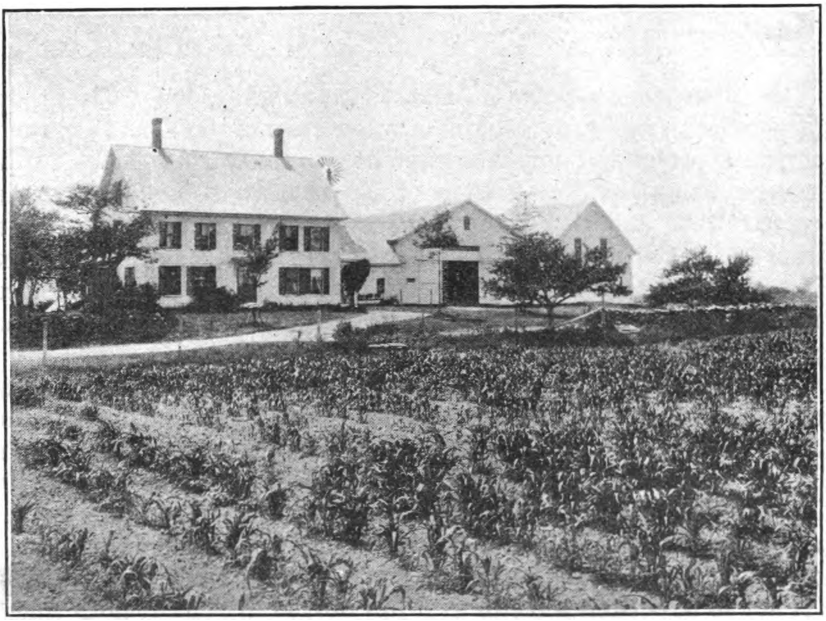

FIG. 1.—Buildings on a farm in the Suncook Valley, N. H. These represent too large an investment in buildings for the average farm of the region in which data were obtained.

TABLE III.—*Comparative distribution of receipts on 200 selected farms and on all the 428 farms in New Hampshire of which data were obtained.*

Item.	100 better farms.	100 poorer farms.	Average, 428 farms.
Crop sales	$347	$136	$262
Net live-stock sales	260	121	162
Sale of stock products	1,389	612	814
Increased inventory	184	30	110
Outside labor	138	32	91
Total receipts	2,318	931	1,439

The receipts from the better farms exceed those of the poorer by 149 per cent. The receipts from sales of stock and of stock products were each more than twice as great on the better farms as on the poorer. The crop sales on the better farms amounted to more than two-and-a-half times as much as on the poorer farms. The inventory of the better farmers increased $184 a year; that of the poorer only $30 a year. The better farms would seem from that not only to be selling off more products of all kinds, but to be at the same time improving the total value of the business. This improvement may be in the raising of more young stock, or in the building up of the real estate, or the adding to the equipment of tools and the like. The final item of receipts, namely, that from labor performed off the farm, is seen to be over four times as great on the better farms as on the poorer. This fact suggests that the farmers on the better farms were more careful to keep the men and teams busy at outside work during such times as they were not fully occupied with their farm work. On the other hand, this item might be the result of a condition wherein those better farmers were merely more fortunate in having outside work presented to them.

TABLE IV.—*Comparative distribution of expenses on 200 selected farms and on all the 428 farms in New Hampshire of which data were obtained.*

Item.	100 better farms.	100 poorer farms.	Average, 428 farms.	Item.	100 better farms.	100 poorer farms.	Average, 428 farms.
Hire of labor	$259	$181	$173	Silo filling	$11	$6	$8
Board of labor	76	74	59	Horseshoeing	24	20	20
Seeds	21	14	15	Milk hauling	11	11	8
Fertilizers	64	37	40	Taxes	73	78	66
Hay	17	11	15	All other expenses	38	40	40
Feed and grains	398	258	284				
Machinery	45	22	28	Total	1,083	792	796
Buildings and repairs	46	40	40				

The average expenses per farm on the better farms were $291 or 36.7 per cent greater than on the poorer farms. This should be compared with the difference between the two groups in receipts, in which respect the better group exceeded the poorer by $1,387, or 149 per cent per farm. Greater profits do not therefore come from reduced expenses, but from an increased outlay and a much greater increase in receipts.

The better farmers spent over one-third more for hired labor than the poorer, and at the same time only $2 more for the board of laborers. This suggests that the better farmers employed higher priced help though no greater numbers, or employed more by the day or otherwise without providing board. In short, the better group of farms used more labor without a corresponding increase in the amount of board furnished them in the farmers' households. The better farms expended 50 per cent more for seed and nearly twice as much for fertilizers as the poorer. In the largest item of expense—feed and grain—the better farmers exceeded the other group by over 54 per cent. The better farmers spent slightly more than twice as much on machinery as the poorer, but very little more on buildings and repairs. That is, the better farmers put money into production, but the expense for upkeep was noticeably much alike in the two groups.

The better farmers purchased more hay, though the total hay purchased by either group is trifling. The better farmers expended nearly twice as much in silo filling and one-fifth more for horseshoeing. The latter was perhaps necessitated by so much more work away from the farm, which was shown in the distribution of receipts.

The milk-hauling cost is the same in both groups, though the quantity of milk sold is much greater on the better farms. It costs just as much to send 50 quarts of milk per day to the railroad station as to send 125 quarts per day.

The taxes are 6.4 per cent less on the better farms. This tax item again has some relation to the distribution of capital, for the better farms had a smaller investment in real estate, of which the whole is taxable, and a greater one in movable property, of which only part is taxed.

TABLE V.—*Comparative number and value of the live stock on 200 selected farms and on all the 428 farms in New Hampshire of which data were obtained.*

Item.	100 better farms.	100 poorer farms.	Average, 428 farms.
Average number of cows	16	10	12
Average value per cow	$47	$45	$47
Sales of dairy products	$1,290	$559	$746
Sales of dairy products per cow	$80.62	$55.90	$62.16
Average number of horses	3	3	2.7
Average value of horses	$148	$134	$133
Average total of animal units	27	18	19.2

The better farms supported 60 per cent more cows than the poorer and while their value per head was reckoned as only $2 more on the better farms the sales of dairy products amounted to almost $25 more per cow. This suggests that sufficient records of the production of cows are not kept to establish their real values. Better care and feeding may be responsible for much of the difference in production, but it is also likely that most cows are not valued according to their natural producing capacity.

The better farmers kept the same average number of horses as the poorer, but their value was $14 a head greater on the better farms. This difference in value is not in proportion to the difference in earnings from outside labor, as the latter appears in the distribution of receipts.

The better farms have 50 per cent more animal units than the poorer group, corresponding to the greater investment in live stock as well as other movable property.

Table VI.—*Comparison of miscellaneous factors on 200 selected farms and on all the 428 farms in New Hampshire of which data were obtained.*

Item.	100 better farms.	100 poorer farms.	Average, 428 farms.
Age of farmer........years..	48	56	51
Interest on investment........	$360	$348	$308
Family labor........	$53	$130	$70
Labor income........	$830	$341	$266

The farmers operating the better 100 farms were on the average 8 years younger than those on the poorer 100 farms. The better farms had a larger interest charge by $12 than the poorer, corresponding to the small difference in investment. The better farms had the help of the family in farm labor to a value of less than 40 per cent of that on the poorer farms, a difference of $77. It will be remembered that the better farms had a cash outlay for hired labor of $78 more than that of the poorer. The total labor value, aside from the farmer's own time, was on the poorer farms almost the same as on the better. The greater proportion supplied by the family on the poorer farms does not seem to have been used so efficiently as the greater proportion of hired labor on the better farms. On the poorer farms the whole family evidently worked harder than on the better and to no purpose, for it will be remembered that the labor income of the better farms was $830 against a minus labor income of $341 on the poorer.

COMPARISON OF THREE AVERAGE FARMS.

Three farms have been selected from those surveyed, and the results are given here to show the character of the individual farms. Two of these farms, Nos. 1 and 2, are successful, and the other, No. 3, shows a minus labor income.

FARM NO. 1.

TABLE VII.—*Statement of the business of farm No. 1.*

[Area, 195 acres; 43 tillable.]

CROP RECORD.

Crop.	Acreage.	Unit of yield.	Yield per acre.
Silage corn	7	Tons	14
Hay	21	...do	3.4
Clover hay (2 crops)	6	...do	5
Oats	7	Bushels	65
Potatoes	2	...do	173

FINANCIAL STATEMENT.

Item.	Amount.	Total.
Capital		$9,767
Real estate	$7,000	
Machinery and tools	500	
3 horses	216	
20 cows [1]	950	
20 hogs	200	
40 chickens	20	
Other live stock	345	
Miscellaneous	536	
Receipts		3,688
Potatoes	195	
Live stock (net)	625	
Hogs	385	
Creamery milk	2,433	
Eggs	50	
Expenses		2,327
Labor and board	780	
Seeds	18	
Grain for feed	1,000	
Fertilizers	100	
Machinery	225	
All other expenses	204	
Farm income		1,361
Less interest at 5 per cent on capital		488
Labor income		873

[1] Receipts per cow (milk), $121; value per cow (grade Jersey breed), $47.

The statement of the business for a year on farm No. 1 is taken from a farm in the Haverhill district which reported high yields of crops and animal products. It is a good example of a dairy farm, having a cropping system much better than the average, but still having rather a larger proportion of hay to other crops in respect to acreage. The production per cow was 7,586 pounds of milk for the year, a high average, indicating good cows, well cared for.

Two men and three horses have been employed on this farm during the year. What they produced to sell was almost wholly live stock or live-stock products, the only exception being less than $200 worth of potatoes. The expense for labor is considerable, and part of this was required for the cows, since they were evidently well cared for. Twenty hogs and a number of pigs also required labor, and these must also have consumed much of the purchased grain which formed a large item among the expenses. Both the total acreage and that tillable are about the average of the better 100 farms surveyed. The investment is larger than the average of the 100 farms and the labor income is also larger. It would seem that the labor used on this farm in connection with the live stock could at the same time have grown more crops to sell. Even with the available tillable acreage this labor might have raised more cash crops by making some slight changes in the rotation. For instance, a larger acreage of potatoes could have been cared for. The owner of farm No. 1 is not keeping more labor, because he is an older man. He is more than 20 years older than the owner of farm No. 2.

FARM NO. 2.

TABLE VIII.—*Statement of the business of farm No. 2.*

[Area, 200 acres; 50 tillable.]

CROP RECORD.

Crop.	Acreage.	Unit of yield.	Yield per acre.
Corn	2	Bushels	50
Potatoes	3	....do	200
Silage corn	6	Tons	15
Oats and peas	5	....do	2.4
Hay	26	....do	2
Clover	5	....do	3.4

FINANCIAL STATEMENT.

Item.	Amount.	Total.
Capital		$8,117
Real estate	$5,150	
Machinery and tools	550	
16 cows [1]	1,200	
3 horses	450	
4 hogs	65	
100 chickens	100	
Other live stock	272	
Miscellaneous	330	
Receipts		3,025
Potatoes	322	
Apples	95	
Wood	50	
Market milk	1,553	
Eggs	160	
Live stock (net)	190	
Increase in inventory	655	
Expenses		1,250
Labor	50	
Seeds	30	
Grain for feed	450	
Fertilizer	200	
Machinery	50	
All other expenses	470	
Farm income		1,775
Less interest at 5 per cent		406
Labor income		1,369

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[1] Receipts per cow (milk), $91; value per cow (grade Holstein breed), $75.

The statement of farm No. 2 illustrates a successful market-milk farm in the Suncook Valley. The crop yields are above the average, as are the receipts per cow from milk sales. The cash receipts from other sources than live stock were over $450, and this farmer's total inventory had also increased $655 during the year, adding that amount to the real income of the farm. Of that increase only $115 was in the form of live stock, the remainder being in improved land and buildings, more machinery and tools, and more feed on hand.

This farm is very closely representative of the average of the better 100 farms in total and tillable acreage, but has about $900 more total investment and a much larger labor income than that 100. A shorter rotation would evidently have given larger yields of hay and forage crops and so would allow somewhat more of the acreage to be used for crops to sell.

It will be well to compare these two farms. Farm No. 1 has a larger investment than farm No. 2 by $1,650, but a smaller labor income by almost $500. Farm No. 1 has $663 more receipts, but $1,077 more cash expenses. The greater receipts of farm No. 1 are primarily from sales of hogs and milk, the milk going to the creamery. The greater expenses are primarily in the items of hired labor and of purchased feeds. These extra feeds were used in part by more cows and still further by the large number of hogs. Evidently the sale of hogs did not pay a very wide margin above the cost of the grain purchased for them. The cows on farm No. 1 produced more value in milk per head than those on farm No. 2, but were not themselves valued so highly by their owner. This is very probably due to the fact that Jerseys (kept on farm No. 1) are not in such demand to ship out of the State as are Holsteins (kept on farm No. 2).

The difference in labor between these two farms brings out a point of much value. Farm No. 2, with an average of 16 cows on hand during the year, was operated by the owner with the aid of only $50 worth of hired labor. He did not receive quite so large yields of his crops as were attained on farm No. 1, but he was able to grow more crops and at the same time take care of about all the cows the average man is willing to milk regularly. Of the 16 cows, presumably not all were in milk at any one time, or at least not for long. On the other hand, the farmer on No. 1 kept at least one hired man all the year and used much extra labor during the busy periods.

The one extra man would be required in most cases to help milk and care for the live stock on farm No. 1, where there are 20 cows and also a few more young cattle and many more hogs than on farm No. 2. At the same time this labor did not raise proportionately more crops either to feed or to sell than did the owner alone on farm No. 2.

In short, No. 2 is a good one-man farm, while No. 1 must be worked by two men on account of the live stock. These men are not employed on crops during the part of the day when they are not needed for the stock. To make farm No. 1 comparable to No. 2, the labor used on No. 1 should take care of about 30 cows and work the crops on about twice the acreage that they are now working. When the regular work, such as milking, is just a little too much for one man, it should either be reduced to what one man can do or work should be found to keep two men reasonably busy all the time.

FARM NO. 3.

TABLE IX.—*Statement of the business of farm No. 3.*

[Area, 150 acres; 50 tillable.]

CROP RECORD.

Crop.	Acreage.	Unit of yield.	Yield per acre.
Corn	2	Bushels	50
Potatoes	1	....do	150
Oats (fodder)	2	Tons	2.5
Hay	40	....do	.37
Clover	5	....do	1

FINANCIAL STATEMENT.

Item.	Amount.	Total.
Capital		$7,826
Real estate	$7,000	
Machinery and tools	200	
4 cows	200	
1 horse	200	
20 chickens	13	
Other live stock	68	
Miscellaneous	145	
Receipts		587
Potatoes	65	
Apples	41	
Market milk	320	
Eggs	25	
Live stock (net)	136	
Expenses		422
Labor	50	
Seeds	10	
Grain for feed	60	
Fertilizers	15	
All other cash	141	
Decreased inventory	146	
Farm income		165
Less interest at 5 per cent		391
Labor income		−226

The statement of farm No. 3 illustrates in many respects the average of the poorer 100 farms. It comprises a smaller total acreage and a little more tillable acreage than the average of the 100. The labor income of No. 3 is not so far on the wrong side as in the average of the 100. The principal reason for this is that this farm is not doing so much business, and though it is badly managed the amount of mismanaged business is not sufficient to cause the loss shown as the average of the poorer 100.

If this farm had had more cows (10 being the number on the average of the poorer 100 farms), it evidently would have shown a worse statement of labor income than it did, provided, of course, the farm was managed on about the same basis as at present. With that condition it would have been nearly typical of the poorer 100 farms.

Compared with the two successful farms, Nos. 1 and 2, farm No. 3 illustrates why many farms in the regions surveyed do not yield a profit. The owner of this farm has just as many acres of tillable land as either of the other men, but he is not utilizing it. He is plowing so small a proportion of the tillable area each year that the rotation is a very long one and the result is a very low average yield of hay. This will neither feed a dairy herd economically nor allow any profitable cash crops to be grown to add to the income. The distribution of the capital on farm No. 3 also illustrates a common difficulty. This farmer estimated the value of his house at $3,000, while the owner of farm No. 1 estimated his at $2,000 and the owner of No. 2 at $1,000. The house is a form of investment which does not contribute toward the income of the farm and the least successful of these three farmers had the most money in that item, while he had the least in the various forms of working capital, including live stock, tools and machinery, supplies, and cash to run the business. This farmer also considered his time worth $500 per year, the same value which the owner of No. 1 placed upon his time. The owner of No. 2, however, set the value of his time at $600 and, as we have already seen, was fully justified in doing so.

SUMMARY.

A summary of the striking points of comparison between the two groups of farms is as follows: The better 100 farms have a labor income of $830 against a minus labor income of $341 for the poorer 100.

The better farms have returned these larger profits with only 21 more acres of total area and about $200 more total investment. Much less of the investment of the better farms was in real estate, however, and more of it in working capital.

The receipts of the better farms were much more than twice as great as those of the poorer farms, being greater in every class. On the other hand, the total expenses were nearly one-third greater, this increase being especially in a few items of productive expense, such as feeds and fertilizers.

The better farms kept one-half more cows and the same number of horses.

The better farms disclosed a markedly greater production per cow in money value, which would warrant a greater difference in the value of cows on the basis of production.

The better farms were operated by men 8 years younger, on an average, than those on the poorer farms and with much less help from other members of the family in farm work.

The more successful group of farmers is making more money, using only a little more capital and a few more acres and following much the same type of farming. While these factors—acreage and capital—have a little influence on the labor income in the regions studied, they do not seem to have so much effect as they have in some other regions studied in the same way. In such regions as these in New Hampshire, geographic conditions usually limit the acreage of tillage land a farmer can have in contiguous area, while the markets within his reach allow him to make considerable modification in his system of farming. Just the opposite limitations prevail in such a region as central Iowa, where it is much easier to get more adjoining land than it is to modify the system of farming.

The success of these better farmers in New Hampshire is due to more and better crops, more productive herds, and thus to more efficient use of their land and their time. The poorer farmers have more idle capital in the form of real estate which is not producing annual returns. Though part of this idle capital is in the form of buildings, much more is in the form of woodland, from which the return may come only at intervals of perhaps 20 or more years. The records of many of these farms do not fall on a year when these returns from wood were obtained. If these occasional receipts were distributed over the intervening years, there would be a tendency for the labor incomes of these poorer farms to be somewhat higher. The farm wood lot is a considerable source of income in these regions.

The comparisons given in this circular all indicate that the farmer in these sections of New Hampshire who makes a good income does so primarily by doing both more business and a better quality of business, although he had no better opportunities than were enjoyed by other men.

[Cir. 128—B]

THE STRENGTH OF TEXTILE PLANT FIBERS.[1]

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INTRODUCTION.

Tensile strength is the most important character of fibers used in making yarn, twine, thread, and woven goods. This one character must be combined with sufficient flexibility, fineness, length, uniformity of diameter, and smoothness to be suitable for spinning, but strength must be regarded as a prime factor.

In nearly all textile mills tests are made of yarns, twines, ropes, and also of woven goods made up of yarns, but very little has been done heretofore to actually measure the strength of individual raw fibers. A list of the "strongest fiber known" would fill several pages, and in the absence of accurate measurements superlative claims are reasonably safe from authoritative contradiction.

A paper [2] on the methods of testing fibers and giving the results of numerous tests of tensile strengths of single fibers was published in Java in 1908, but this excellent treatise in the Dutch language is little known in this country.

Many different kinds of machines have been devised for testing yarns, and some of these which are especially accurate in a low range are suitable for single fibers. A machine for testing cotton must be accurate in a range from 2 to 20 grams and one for testing long, hard fibers from 100 to 10,000 grams.

STRENGTH OF COTTON FIBERS.

More than a thousand samples of cotton fibers have been tested in the Office of Fiber Investigations. The machine (fig. 1) used in making these tests is based on the principle of balances, with a sliding brass bar instead of weights. The operator moves the bar steadily and without any jar by means of a thumbscrew which turns a ratchet wheel touching teeth on the bar. A single fiber picked up by the double forceps is placed in the jaws of the machine, the rounded faces of which, pressed together with springs, hold the fiber firmly but do not cut it. The weight is added by turning the thumbscrew with a uniform motion, and the breaking strain is read on the dial in tenths of grams. Twenty fibers are thus broken, one at a time. The breaking strain of each is recorded, showing the variation, and the average is determined as the tensile strength of the sample.

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[1] Issued May 24, 1913.

[2] Havik, H. G. Laboratorium vor het onderzoek van vezelstoffen. Jaarboek, Departement van Landbouw, Nederlandsch-Indië, 1908, p. 319–333, 2 pl., 1909.

While there is much variation in every sample, it has been found by numerous trials that the average breaking strain of 20 fibers is approximately the same as that of a larger number. This is especially true of seed cotton, where it is possible to take one fiber from each of 20 different seeds. Furthermore, it is found that the fibers taken from midway on the side of the seed are more uniform than those at either end. Those at the pointed end are most variable.

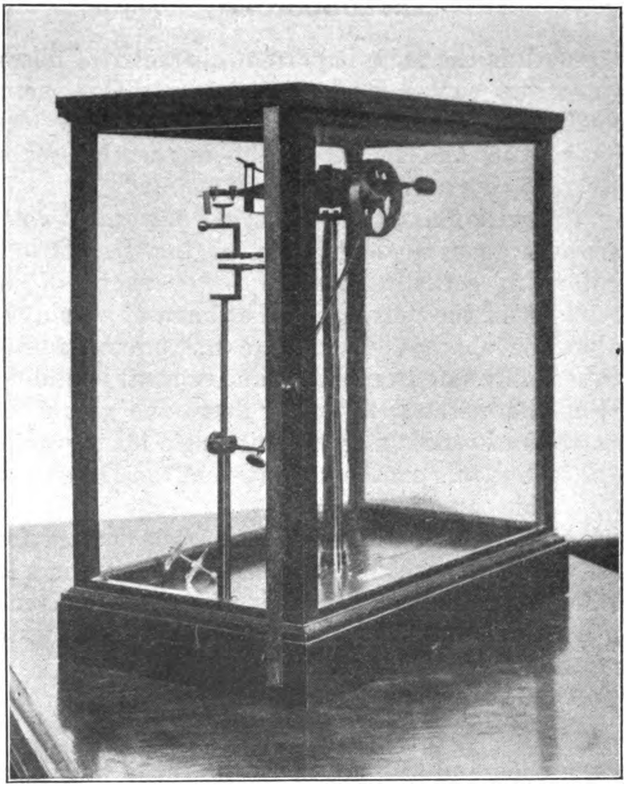

FIG. 1.—Fiber tester, with a capacity of 0.1 to 50 grams, used for determining the strength of cotton fibers.

The results from a large number of tests of samples from nearly all of the prominent varieties in the seven different groups of American Upland cotton, and also Sea Island and Egyptian cottons, are condensed in Table I.

TABLE I.—*Tensile strength of cotton fibers.*

Variety of cotton.	Breaking strain (grams).		
	Highest.	Lowest.	Average.
American Upland (Gossypium hirsutum):			
Big-Boll Stormproof group	9.0	5.2	6.67
Big-Boll group	11.6	4.6	6.60
Cluster group	7.7	5.1	6.00
Semicluster group	7.1	4.7	5.86
Peterkin group	6.0	5.0	5.70
Early group	6.9	5.2	5.63
Long-staple group	5.6	3.5	4.72
Sea Island (Gossypium barbadense)	7.6	4.7	6.14
Egyptian (Gossypium barbadense):			
From Arizona and California	8.0	5.6	6.65

The highest and lowest figures given in the foregoing table are the averages for 20 fibers, not the highest and lowest breaking strain of single fibers. The tensile strength of single fibers of American Upland cotton is generally in inverse ratio to their length, though the longer staples make stronger yarns. The strength is in more direct ratio to the diameter. The accurate measurement of the diameters of the twisted, ribbonlike cotton fibers presents such difficulties and requires so much time that it is not included in all tests. Measurements by means of a microscope with an eyepiece micrometer have been made of more than 100 samples. A summary of these measurements is shown in Table II.

TABLE II.—*Diameters of cotton fibers.*

Variety of cotton.	Diameter (microns).[1]		
	Maximum.	Minimum.	Average.
American Upland (short staple)	34.80	28.80	31.88
Sea Island	28.10	21.75	24.31
Egyptian (American grown)	28.10	18.40	23.30

[1] 1 micron=0.001 millimeter, or nearly 0.00004 inch.

A series of tests has also been made to determine the pull necessary to detach the fiber from the seed. In American Upland varieties this ranges from 1.88 to 2.3 grams, and in Sea Island from 1.75 to 1.95 grams.

STRENGTH OF LONG FIBERS.

The long fibers constitute two natural groups: (1) Soft fibers, or bast fibers, such as flax, hemp, jute, and ramie; (2) hard fibers, such as abacá (Manila hemp), henequen, sisal, and phormium (New Zealand hemp). The strands of the soft fibers vary greatly in thickness and they usually cling together in such a manner as to make it practically impossible to select single strands for comparison. The hard fibers, however, present single strands sufficiently uniform and free from other strands to be selected for breaking, but they are not uniform enough to be directly compared. A coarse, hard fiber may break at a higher tensile strain than a finer one, yet the fine one may be much stronger when compared with equal bulk or weight for weight. Weight is more satisfactory for comparison than diameter or bulk and it is more easily determined. For comparison, therefore, the breaking strain of each sample is computed to the convenient but arbitrary standard of a fiber weighing 1 gram per meter of length.

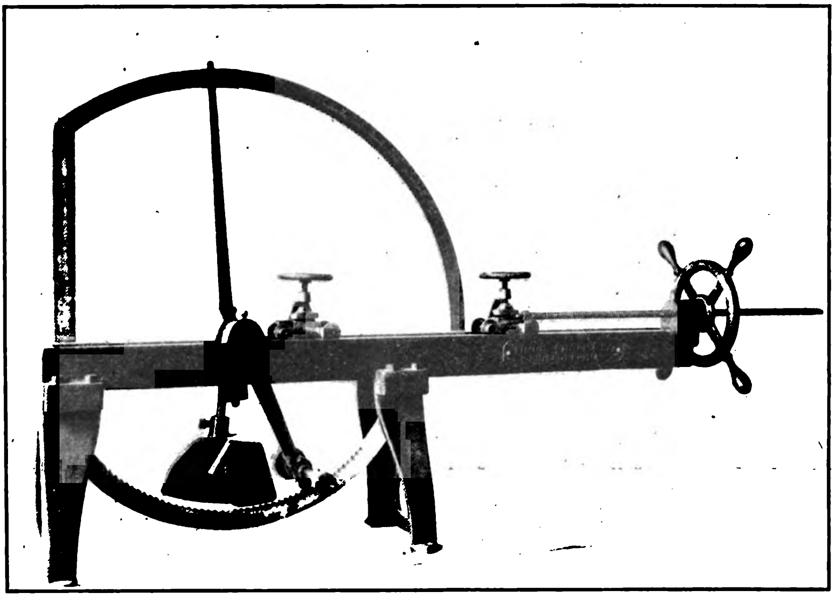

FIG. 2.—Testing machine with a capacity of 1 gram to 90 kilograms, used for determining the strength of hard fibers.

In testing hard fibers the following method is pursued:

Twenty fibers are selected from the sample and their length measured, after which they are weighed and the total weight is divided by the total length, giving the average weight per meter. They are then broken, one at a time, in the testing machine. (Fig. 2.) The average breaking strain divided by the average weight per meter gives the breaking strain per gram meter.

The results of numerous tests of some of the principal hard fibers are given in Table III.

TABLE III.—*Weight and breaking strain of hard fibers.*

Fiber.	Weight per meter.	Average breaking strain per strand.	Breaking strain per gram meter.
Abacá (Manila hemp), Musa textilis:	*Gram.*	*Grams.*	*Grams.*
Highest	0.04019	3,020	75,143
Lowest	.06817	2,012	29,521
Average	.05470	2,254	45,115
Henequen (Yucatan sisal), Agave fourcroydes	.05420	1,085	20,021
Sisal (Hawaii and East Africa), Agave sisalana	.04370	1,472	32,773
Cantala (Manila maguey), Agave cantala	.03040	625	2,055
Phormium (New Zealand hemp), Phormium tenax	.04670	1,222	26,159
Zapupe Vincent (Agave lespinassei)	.05120	1,394	27,198
Cabuya (from Costa Rica), Furcraea cabuya	.04070	1,297	31,933

Several different grades of abacá are recognized in the market, the differences being due chiefly to greater or less care in cleaning the fiber, and therefore this fiber presents a wide variation in weight per meter and in strength. The highest and lowest figures given in the foregoing table do not represent the extreme limits. Henequen and sisal cleaned by machinery are more uniform.

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